Fermilab

Directorate

MEMORANDUM OF UNDERSTANDING

FOR THE 2011 FERMILAB TEST BEAM FACILITY PROGRAM

T-1011

Tests of radiation-hard silicon microstrip sensors for CMS in S-LHC

February 21, 2011

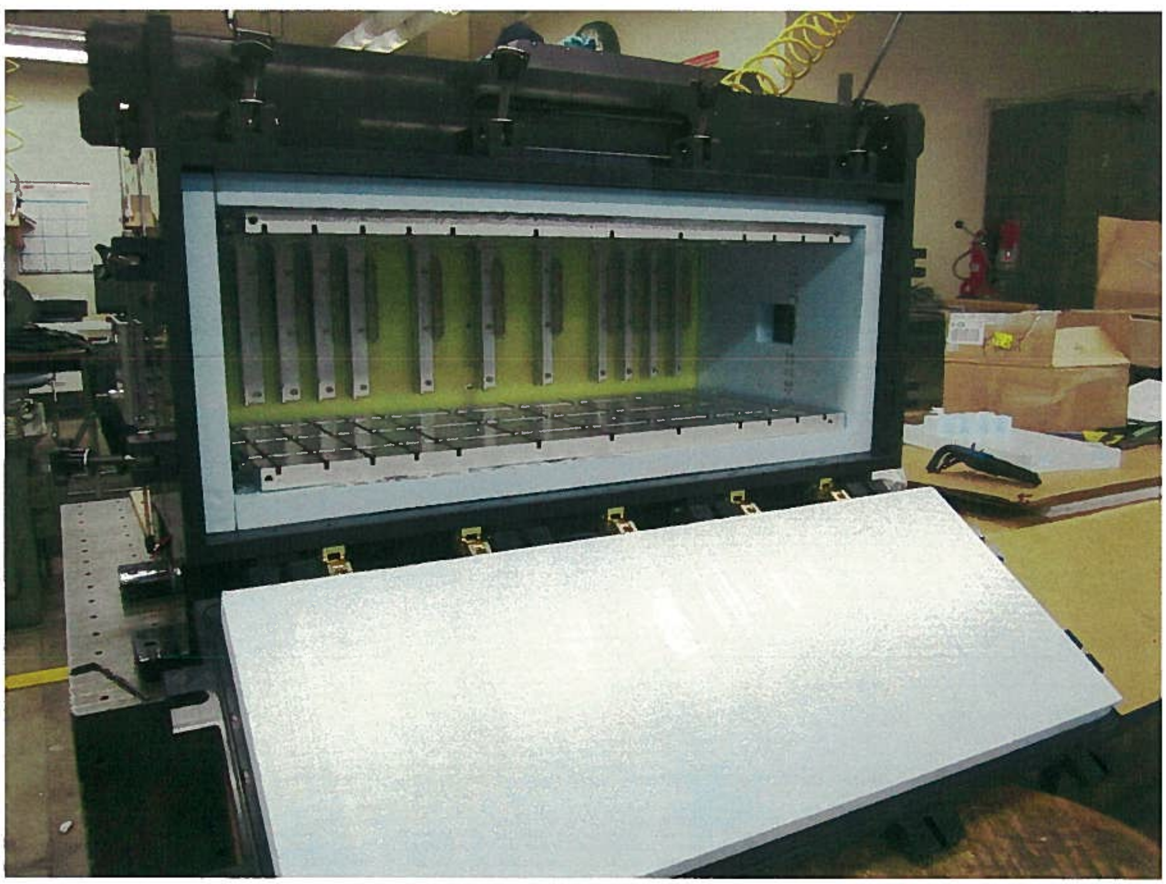

TABLE OF CONTENTS

INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of the CMS SiBT group, which consists of individuals from the Helsinki Institute of Physics, Brown University, the Fermi National Accelerator Laboratory, Universität Karlsruhe, and the University of Rochester who have committed to participate in beam tests to be carried out during the 2011 Fermilab Test Beam Facility program.

The memorandum is intended solely for the purpose of recording expectations for budget estimates and work allocations for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to modify this memorandum to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

Description of Detector and Tests:

The tests are to study the performance of various silicon microstrip sensors that are sufficiently radiation-hard to be considered as candidates for the CMS outer (R>25cm) tracker in the second phase of the currently envisioned S-LHC upgrade.

The main goal of the beam test is to test Float Zone (FZ) and Magnetic Czochralski (MCz) silicon sensors that have been procured from Hamamatsu by the CMS collaboration as possible replacements for the CMS outer tracker for phase 2 operations. The detectors under test (DUT) will be installed in a cold box that contains 10 slots for modules based on CMS Tracker hybrids. Slots 1-4 and 7-10 are occupied by reference planes and slots 5 and 6 are reserved for DUTs. The box is cooled by Peltier elements in thermal contact with the top and bottom aluminum baseplates and is typically operated at around -25°C. A PCI based version of the CMS DAQ is used to read out the 10 slots based on triggers provided by beam scintillation counters. Given the low rate of beam particles the hybrid APVs will be operated in Peak mode, which maximizes the signal-to-noise performance of the readout chips. The internal clock operates at the LHC frequency of 40 MHz.

By reconstructing beam tracks in the 8 reference planes and interpolating to the centrally located DUTs, the CMS/SiBT group will be able to study the noise, signal, signal-to-noise, and position resolutions of irradiated and non-irradiated HKP prototype sensors. Standard CMS software will be used to reconstruct tracks with DUT impact parameter uncertainties of around 4 μm for both the +45° and -45° sensor orientations within the cold box. The fluence levels, which are based on proton, neutron, and mixed exposures, will be chosen to span the range expected in S-LHC running.

If time permits the CMS/SiBT group also proposes to install modules based on mini-sensors (~1 cm^2) prepared in the Helsinki University of Technology Micro and Nanofabrication Centre (MINFAB) facility in Finland by the Helsinki group. Some of the mini-sensors contain Al_2O_3 based capacitive-coupling structures that have been built into the pitch adapter (and hence the sensors have an older style direct coupling design); the beam tests will probe the viability of this technique for large-scale systems (such as S-CMS) where a DC sensor design could result in considerable cost saving. All of the modules will have CMS Tracker hybrids in common.

The CMS/SiBT group has had five separate beam tests in the CERN H2 beamline since 2006 using the CMS DAQ based telescope; the most recent test took place in November 2010. The University of Rochester has recently completed a new cold box, to replace the module burn-in box provided by FNAL at the end of the module construction period, and this will be shipped to Fermilab in January for wiring. However, the default plan will be to run with the existing system.

Additional information on the CMS/SiBT group and results from previous beam studies can be found at

http://www.hip.fi/research/cms/tracker/SiBT/php/home.php

The CMS/SiBT group also works closely with the CERN RD50 and RD39 collaborations.

I. PERSONNEL AND INSTITUTIONS:

Spokesperson: Panja Luukka (Helsinki)

Physicist in charge of beam tests: Lenny Spiegel (FNAL)

Fermilab liaison: Aria Soha

The members of the group who will take part in the installation, data taking activity, data analysis, and dismantling at Fermilab are:

	Institution	Collaborator	Country	Rank/Position	Other Commitments
1.1	University of Rochester	Robert Flight	USA	Mech. Eng.	
1.2	Helsinki Institute of Physics	Panja Luukka	Finland	Physicist	CMS
		Teppo Mäenpää	Finland	Physicist	CMS
		Esa Tuovinen	Finland	Physicist	CMS
1.3	Fermilab	Lenny Spiegel	USA	Physicist	CMS

The SiBT group will also draw on expertise as necessary from T-992 experimenters:

Simon Kwan (FNAL)

JC Yun (FNAL)

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 BEAMLINE

The beam test(s) will take place in MT6-2B, behind the T-992 telescope.

2.1.2 Work space within FTBF shall be provided for mounting modules on telescope insertion plates and making minor modifications (e.g. soldering wires) to the insertion plate adapter boards. This shall include a couple standard work benches in a low dust environment with adequate lighting.

2.1.3 The experimenters plan to use the MTest Control Room. Additional meeting space including two or more desks and network connectivity will be provided for the duration of the test.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 120 GeV proton beam
Intensity: 10k – 100k in units of particles/4 sec spill
Beam spot size: about 10 cm^2 (The SiBT sensors are 4cm x 4cm.)

2.2.2 BEAM SHARING

Beam will be shared with T-992. The two systems are independent of each other and can run at the same time. The SiBT group understands that as secondary users it will be necessary to get permission from T-992 for controlled accesses and to have the beam parameters adjusted.

2.3 EXPERIMENTAL CONDITIONS

2.3.1 APPARATUS

The detectors under test (DUT) will be installed in a cold box that contains 10 slots for modules based on CMS Tracker hybrids. Slots 1-4 and 7-10 are occupied by reference planes and slots 5 and 6 are reserved for DUTs. The box is cooled by Peltier elements in thermal contact with the top and bottom aluminum baseplates and is typically operated at around -25°C. A PCI based version of the CMS DAQ is used to read out the 10 slots based on triggers provided by beam scintillation counters.

A remotely-operable XY table will be provided by Fermilab to support the beam telescope in the beamline and to allow fine adjustments (small steps ~1mm) in the transverse directions. The dimensions of the support plate for the telescope cold box are 138 cm by 66 cm and the combined weight of the box and plate is approximately 100 kg.

A standard Neslab or equivalent recirculating chiller (>3.5kW cooling capacity, 3 bar operating pressure) will be provided by Fermilab for removing heat from the Peltier elements in the cold box. The chiller should have hosing compatible with the quick disconnects on the side of the cold box and, if possible, be located outside of the key access area.

A dry nitrogen source will be provided by Fermilab for the cold box module and Peltier element enclosures.

2.3.2 Electronics Needs

The experiment will make sure all electronics provided by the experiment are electrically and mechanically compatible with US 110V outlets. Fermilab will provide US 110V power for the DAQ system and associated computers; and 220V power for the chiller.

The experiment will provide a readout system compatible with the CMS AVP-based telescope modules, a CAEN crate for biasing the modules, and two small beam counters that attach to the cold box. Fermilab will provide signal and HV cables between the control room and telescope for operating the beam counters and communicating with the DAQ computers, and CAEN and Peltier power supplies. A special HV supply, provided by the experiment, may be used to bias modules up to ~1200V. No exposed HV parts will be present and all operations will be attended.

2.3.3 Description of Tests

Tests consist of inserting two or more Detectors Under Test in the telescope, setting the box temperature to around -25°C and adjusting the sensor bias voltages, typically in 10V steps where each step corresponds to about 50k triggers. Modules will be exchanged during the beam off periods and the voltage scans should consume much of the 12-hour beam periods. An online package is used to reconstruct tracks, so it is fairly straightforward to adjust the XY table so the beam is well centered on the DUT sensors. Prior to cooling down the box, a check will be made to verify that all sensors are bias-able as installed in the box and there are no readout issues.

Much of the voltage scanning has been automated, but the experimenters will have two people present during beam operations to verify the data makes sense and to access the enclosure if there are any issues. Accesses should be rare, given the ample time between beam periods and the experimenters experience with the system.

2.4 Schedule

A two-week running period starting on March 16, 2011 will be provided with some access to the area in the preceding week for staging equipment. If there is a slippage in the schedule the experiment liaison should be notified as soon as possible as the travel schedules for the beam telescope DAQ experts may not be completely flexible.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

The personnel from the participating institutes will provide and set up equipment on the beamline under the guidance and supervision of the Fermilab Particle Physics Division, provide the DAQ and power supplies for the DAQ, Peltier elements, and detector HV, and provide run coordination and funding for its personnel for the beam test.

3.1 UNIVERSITY OF HELSINKI

The beam telescope including the cold box, DAQ electronics and PCs, scintillation counters, CAEN crate and modules, and power supplies will be shipped from CERN to Fermilab for the beam test. The University of Helsinki is the custodian for the system and the approximate value of the system is around $40,000. This does not include the CAEN electronics, which belong to the CERN Electronics Pool. [$40K]

3.2 ROCHESTER UNIVERSITY

Rochester University with some help from Fermilab has recently produced a second cold box that has additional module slots (12 instead of 10) compared with the recycled CMS module burn-in cold box and other improvements as well. The approximate value of the new box is $20,000. If there are no issues with the temperature control of the new box, the experimenters may want to use this in place of the standard cold box. However, the default position will be to use the standard system for the beam tests. [$20K]

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beam as outlined in Section II.
4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
4.1.3 Scalers and beam counter signals should be made available in the counting house.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to beams control console and remote logging (ACNET) should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR). [1.0 person-weeks]
4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the antiproton stacking rate and the neutrino flux by more than 5% globally, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION:

4.2.1 The test-beam efforts in this MOU will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and MTest computers. [2.0 person-weeks]
4.2.2 Set-up and maintenance of the MT6SC1 scintillation counters.
4.2.3 Provide support for the recirculating chiller and assist the experiment in obtaining either distilled water or ethylene-glycol for the chiller operations.
4.2.4 Assistance with the storage and handling of irradiated sensors if they fall within special handling guidelines. (PPD ES&H)

4.3 FERMILAB COMPUTING DIVISION

4.3.1 Internet access should be continuously available in the counting house.

4.4 FERMILAB ES&H SECTION

4.4.1 Assistance with safety reviews.
4.4.2 Provide all necessary training for experimenters.
4.4.3 Assistance with the storage and handling of irradiated sensors if they fall within special handling guidelines. (PPD ES&H)

V. SUMMARY OF COSTS

Source of Funds [$K]	**Materials & Services**	**Labor** (person-weeks)
Particle Physics Division	$2 K	2.0
Accelerator Division	0	1.0
Computing Division	0	0
Totals Fermilab	$2K	3
Totals Non-Fermilab	$60K	7

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the Spokesperson and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Researchers": (http://www.fnal.gov/directorate/PFX/PFX.pdf). The Spokesperson agrees to those responsibilities and to follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ES&H) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The Spokesperson will follow those procedures in a timely manner, as well as any other requirements put forth by the Division's Safety Officer.

6.3 The spokespersons will ensure at least one person is present at the Fermilab Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ES&H section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The Spokespersons will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Computing Division management. The Spokesperson also undertakes to ensure that no modifications of PREP equipment take place without the knowledge and written consent of the Computing Division management.

6.7 The experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

At the completion of the experiment:

6.8 The Spokesperson is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Spokesperson will be required to furnish, in writing, an explanation for any non-return.

6.9 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ES&H requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

6.10 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied.

6.11 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.

MOU for T-1011: Radiation-hard Silicon Microstrip Sensors for CMS

SIGNATURES:

02 /22/ 2011

Panja Luukka, Experiment Spokesperson

2 /23/ 2011

Michael Lindgren, Particle Physics Division, Fermilab

2 / / 2011

Roger Dixon, Accelerator Division, Fermilab

2 /28/ 2011

Peter Cooper, Computing Division, Fermilab

2 /28/ 2011

Nancy Grossman, ES&H Section, Fermilab

2 / 28/2011

Greg Bock, Associate Director for Research, Fermilab

3 / 2/2011

Stuart Henderson, Associate Director for Accelerators, Fermilab

APPENDIX I: - HAZARD IDENTIFICATION CHECKLIST

Cryogenics		**Electrical Equipment**		**Flammable Gases or Liquids**	
	Beam line magnets	X	Cryo/Electrical devices (No Liquids, -25 C)	Type:	
	Analysis magnets		capacitor banks	Flow rate:	
	Target	X	high voltage (1200V)	Capacity:	
	Bubble chamber		exposed equipment over 50 V	**Hazardous/Toxic Materials**	
Pressure Vessels		**Other Gas Emissions**		List hazardous/toxic materials planned for use in a beam line or experimental enclosure:	
	inside diameter	Type:	Nitrogen		
	operating pressure	Flow rate:	0.1 l/min		
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:			Lithium (Li)
	window material	Strength:			Mercury (Hg)
	window thickness	**Hazardous Chemicals**			Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other
	Calibration		Methane	**Mechanical Structures**	
	Alignment		TMAE		Lifting devices
type:			TEA		Motion controllers
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others